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Application of One Server Queuing Models to Customers Management in the Cafeteria: A Case Study of Afe Babalola University, Ado-Ekiti (Abuad)

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ABSTRACT
This paper seeks to clarify the impact of time wasting on the weak performance, efficiency and effectiveness of their operations at Abuad cafeteria by applying queuing theory in a real life situation. We obtained the data from the major cafeteria in Abuad. We then derive the arrival rate, service rate, utilization rate, waiting time in queue. Based on the data Little's Theorem and M/M/1 queuing model was also considered. The arrival rate at at Abuad cafeteria during its busiest period of the day is 2.92 customers per minute (cpm) while the service rate is 2.95 cpm. The average number of customers in the cafeteria is 219 and the utilization period is 0.995. We conclude the paper by given the concluding remark and acknowledge.

KEY WORDS: *Abuad, cafeteria, waiting lines, Little's theorem, Utilization factor, customers.*

1. INTRODUCTION

Queuing theory is the mathematical study of waiting lines which are the most frequently encountered problems in everyday life. For instance, queue at a cafeteria, telecommunication, library, bank, etc. Common to all of these cases are the arrivals of objects requiring service and the attendant delays when the service mechanism is busy. Waiting lines cannot be eliminated completely, but suitable techniques can be used to reduce the waiting time of an object in the system. A long waiting line may result in loss of customers or loss of goodwill to an organization. Waiting time can be reduced by providing additional service facilities, but it may result in an increase in the idle time of the service mechanism. In this paper queuing theory will be apply to the area of cafeteria.

A cafeteria is a type of food service location in which there is a little or no waiting staff table service, whether a restaurant or within an institution such as a large office building or school. University cafeteria which offers a varied menu and comfortable surroundings enable students to experience a sense of ''home'' which on campus which can engage in leisurely conversation and interactive activities with their peers (Norhati and NurHafisah, 2013, Raman and Chinniah, 2011).'

There are several factors for a restaurant to be attract customers, the most important are; task, cleanliness, food quality, service quality, restaurant environment and safety are most important factors (Mishra et al 2013; Haghighi et al 2012). These factors, when managed carefully, will be able to attract plenty of customers. However, there is also another factor that needs to be considered especially when the restaurant has already succeeded in attracting customers. This factors is the customers queuing time. Queuing theory is the study of queue or waiting lines. Some of the analysis that can be derived using queuing theory includes the expected queuing length, the probability of the system to be in certain states, such as empty or full (Dharmawraya and Adi, 2011).

Queuing theory is very common in restaurants especially during lunch and dinner time. Hence, queuing theory is suitable to be applied in a restaurant setting, since it has an associated queue or waiting

line where customers who cannot be served immediately have to queue (wait) for service. Researchers have previously used queuing theory to model the restaurant operation, reduce cycle time in a busy fast food restaurant, as well as to increase throughout and efficiency (Brann and Kuuck, 2002; Curin et al 2005; Kharwat, 1991).

This paper uses queuing theory to study the waiting lines in ABUAD cafeteria. There are three major cafeterias in Abuad, these are: cafe 1, café 2 and the staff cafeteria. Cafeteria provides tables of four people. There are 3 to 6 waiters or waitresses working at any point in time in these entire three cafes. On a daily basis, the three cafes servers over 5000 customers during weekdays, and over 3500 customers during weekends. This paper seeks to clarify the impact of time wasting on the weak performance, efficiency and effectiveness of their operations in Abuad cafeteria by applying queuing theory in a real life situation.

2. QUEUINGTHEORY

Queuing theory is a mathematical approach in operation research applied to the analysis of waiting lines. A.K. Erlang first analyzed queues in 1913 in the contest of telephone facilities. He identified that the number of telephone conversations and telephone holding time put into Poisson distribution and exponentially distributed.

The body of knowledge that developed thereafter via research and analysis came to be known as queuing theory, and is extensively applied in industrial settings and retail sectors.

3. LITTLE'STHEOREM

Little's (1961) little's theorem describes the relationship between throughout café (i.e arrival and service rate), cycle time and work in process. The theorem states that the expected numbers of customers L for a system in steady state can be reduce from Little's theorem.

$$L = \lambda T \quad (1)$$

Where λ the expected number of customers' arrival rate and T is the expected service time for a customer. Three fundamental relationships can be derived from little's theorem (Lag Una & Marklund, 2005)

- L increases if λ or T increases
- λ increases if L increases or T decreases
- T increases if L increases or λ decreases

4. ABUAD RESTAURANT QUEUING MODEL

We will discuss only the single queue model which is:

One server (Queue with M | M | I model)

An M | M | I system is a queuing system having exponential distributed inter arrival time, with parameter λ; exponentially distributed service time, with parameter μ, one server, no limits on the system capacity and a queue discipline of first come first served. The constant λ is the average customer arrival rate while the constant μ is the average service rate of customers. Both are in units of customers per time. The expected inter-arrival time and the expected time to serve one customer are 1/λ and 1/μ respectively. M | M | I systems are often referred to as system with single-server, infinite capacity, queuing systems having Poisson input and exponential service times.

We required that:

$$\rho = \frac{\lambda}{\eta} \text{ : utilization factor} \quad (2)$$

Where λ : the mean customers arrival rate

η : The mean service rate

P_n: the probability of having n customers

Probability of zero customers

$$P_n = (1-\rho)\rho\eta \quad (3)$$

$$Po = 1-\rho \quad (4)$$

L: Expected number of customers dining in the restaurant

$$L = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu-\lambda} \quad (5)$$

L_V: Expected number of customers λ the queue

$$L_v = LxP = \frac{\rho 2}{1-\rho} = \frac{\rho\lambda}{\mu-\lambda} \quad (6)$$

Expected waiting time of customers in the queues

$$Wq = \frac{\rho}{\mu-\lambda} \quad (7)$$

Expected waiting time spent in Abuad restaurant include the waiting time

$$Ws = \frac{1}{\mu-\lambda} \quad (8)$$

5. RESULTS AND DISCUSSION FOR ABUAD CAFETERIA QUEUING SYSTEM ANALYSIS

The data are obtained from all the three major University restaurants through interview with the restaurant manage as well as data collections through observations at the cafeteria. Some students were also interviewed to know their interest derived from those cafeterias.

The daily numbers of visitors were obtained from the cafeteria at managers. The cafeteria has been collated the data as part of their end of day routine through the number of tickets sold out to the visitors based on the interview with the cafeteria managers.

Below is the one month daily customer record which was collected from the cafeteria

Table 1: **one month daily customer sale**

Weeks	*Mon.*	*Tues.*	*Wed.*	*Thur.*	*Fri.*	*Sat.*	*Sun.*
1ST Week	*2317*	*2764*	*3452*	*3389*	*4014*	*4117*	*4513*
2nd Week	*3762*	*3542*	*4072*	*4087*	*4287*	*4592*	*4762*
3rd Week	*4007*	*3231*	*3528*	*4109*	*4511*	*4976*	*4517*
4th Week	*3276*	*3974*	*4121*	*4275*	*4713*	*4727*	*4676*
Total	**13362**	**13511**	**15173**	**15860**	**17525**	**18412**	**18468**

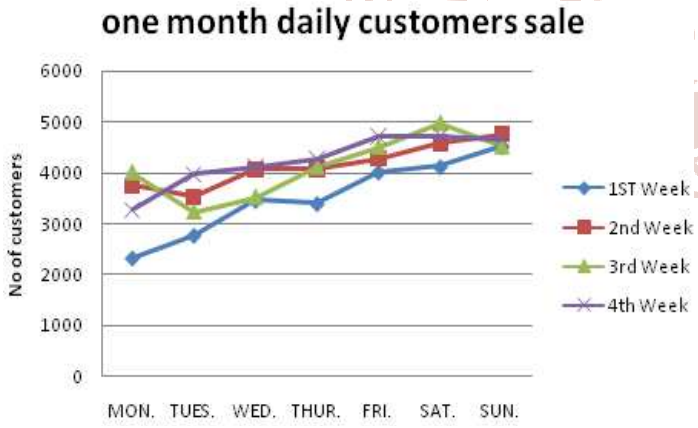

Fig1.

From the fig 1 above it can be deduced that the numbers of customers on Fridays to Sundays are more than the number of customers during the weekdays. The free period for all the students is on weekend so they have time for pleasure.

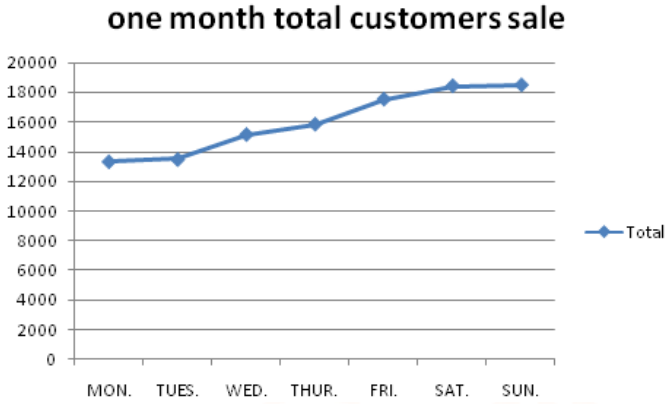

Fig2.

The trend of one month total customers sale is shown the fig.2 above

6. CALCULATION

We conducted the research at abuad cafeteria. There are average 4500 people coming to restaurant in 12 hours' time window of dinner time. We derive arrival rate $\lambda = 4500/720$

$= 6.25$customers/min.

We observed & discussed with managers of the cafeteria that each customers spend 35 min. on average in cafeteria (Ws), the queue length Lq is about 47 people on average & waiting time is nearly 15 minutes, using Wq = Wq=$\frac{\rho}{\mu-\lambda}$the observed actual waiting time is not very much different when compared to the theoretical waiting time. Wq = 47/6.25 = 7.52 minutes Now, calculating average no. of customers in cafeteria using little's formula Ls = λWs = 6.25 × 35 min. = 219 customers Now, we derive utilization rate & service rate

$$Ls=\frac{\rho}{1-\rho}=\frac{\lambda}{\mu-\lambda}$$

$$\mu=\frac{\lambda(1+L)}{L}=\frac{6.25(1+219)}{219}=6.28 \text{ customers/minute}$$

$$\text{Hence, } \rho=\frac{\lambda}{\eta}=\frac{6.25}{6.28}=0.995$$

With very high utilization rate of .995 during dinner time, the probability of zero customers in cafeteria is very small as P_0=1- ρ = 1-.995=.005

7. CONCLUDING REMARKS

- Queuing theory is not new but only recently has restaurant begun to use it effectively.

- The utilization rate at the cafeteria is very large (0.995). This is only utilization rate during lunch and dinner from Monday to Sunday.
- The utilization is directly proportional with the mean number of customers. It means that the mean number of customers will increase as the utilization increases.
- This research can help Abuad cafeteria to increase their (Quality Of Service), by anticipating if there are many customers in the queue
- By anticipating the huge number of customers coming and going in a day, the restaurant can set a target profit that should be achieved daily.

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